Changes in Dietary Intake and Body Weight in Lactating and Non-Lactating Women: Prospective Study in Northern Coastal Croatia

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ABSTRACT

Postpartum weight retention is a risk factor for the development of midlife obesity. Since dietary intake and breastfeeding practice could be promoters of weight loss during postpartum, the objective of this study was to investigate their influence on weight retention during six months postpartum. The study sample consisted of 83 lactating and 76 non-lactating Croatian women who were examined at three measurement waves: at 1 month ±1 week, 3 months ±1 week and 6 months ±1 week postpartum. At each measurement wave, two consecutive 24-hour dietary recalls were collected, and body weight measurements were made. Both groups had a daily energy intake lower by about 25% than recommended. Although both groups continuously decreased energy and macronutrient intake, lactating women had energy intake higher by 205 kcal ($p=0.048$) and 370 kcal ($p<0.001$) after one and three months, respectively. At six months postpartum lactating women had a higher intake of fat ($p=0.036$) but a lower intake of protein ($p=0.009$) compared with non-lactating mothers. After six months, lactating women retained 101.9% of pre-pregnancy weight, which was significantly less than the percentage of weight retained among non-lactating women ($p=0.014$). Multiple regression analysis showed that weight retention were predicted by: type of feeding ($\beta=-0.281$; $p<0.001$), and time since parturition ($\beta=-0.151$; $p<0.001$), while gestational weight gain ($\beta=0.491$; $p<0.001$), energy intake ($b=0.157$; $p<0.001$) and energy derived from fat ($\beta=0.122$; $p=0.035$) were positive predictors. We concluded that the dietary intake of Croatian women and breastfeeding practice over six months significantly influence their weight loss.

Key words: *dietary intake, gestational weight gain, lactation, weight retention, postpartum period*

Introduction

Obesity is a growing problem on a global scale with populations both in developing and affluent countries being at risk. Excess weight and obesity are also one of the major public health issues in Croatia since they can lead to an increase in morbidity and mortality from non-communicable diseases. Based on the results of the Croatian Adult Health Survey, the prevalence of overweight, obesity and increased waist circumference among Croatian women were estimated at 33.60%, 20.60% and 51.13%, respectively[1]. According to these results, Croatia is among the countries with a higher burden of overweight and obesity when compared with other European countries. In Europe, the highest prevalence of obesity among women was recorded in Poland (36.5%), whereas the highest prevalence of overweight among women (about 34%) was in Portugal, Malta and Cyprus[2,3].

The childbearing and the postpartum years, are an important life stage for women that may result in substantial weight gain leading to the development of obesity. In the light of early prevention of obesity, special concern should be taken in counselling women in the period after parturition since they are a very vulnerable population, considering the changes in metabolism and in lifestyle which have occurred. Concerning weight change during postpartum, it was shown that pre-pregnancy BMI, gestational weight gain and diet could be considered as being one of its major determinants[4].

Received for publication January 29, 2014

Weight gain before, during and after pregnancy not only affects the pregnancy but may also be a primary contributor to the future development of obesity in women during midlife and beyond[5,6]. Women are often told that breastfeeding will help them lose weight, but they may have concerns about diet and substantial weight loss and its effect either on their breast milk quality or supply or on the growth of their babies. Evidence is limited and conflicting about whether women who breastfeed their infant lose more weight than women who do not breastfeed[7–11]. From an evolutionary point of view, it appears reasonable to assume that the adipose tissue deposition during pregnancy would serve during breast-feeding as a nutritional reserve to ensure an adequate energy supply for the newborn[12].

Additionally, appropriate dietary intake during postpartum is of particular importance since it strongly determines the health status of mother and infant[13]. Studies conducted on lactating women have shown that a mother´s nutrition has a greater impact on her long-term health than on the quality and quantity of her milk[14]. However, the proportion of ingested nutrients portioned for milk biosynthesis may depend on maternal nutrient stores. These stores may be mobilized to contribute to the nutrient availability for milk biosynthesis, and it is likely that the extent of nutrient mobilization is conditioned by dietary intake[15].

Although the influence of various factors on weight change during postpartum is a frequent topic of discussion, to the best of our knowledge, in the literature up to date, the relationship between dietary intake and weight change during postpartum has not been examined in Croatian women.

Given the importance of various factors which could influence postpartum weight change and given the absence of literature data, the objectives of this work were to investigate how weight retention of women living in Primorsko-Goranska County in Croatia, was affected by: 1) type of feeding; 2) time since parturition; 3) gestational weight gain; 4)total energy intake and 5) energy intake derived from fat.

Subjects and methods

Subjects

In this prospective study, we enrolled and monitored postpartum lactating and non-lactating Croatian women in Primorsko-Goranska County for six months. Data collection lasted 12 months, from January 2009 to January 2010. A total of 180 women, who gave birth to children during 2009, were recruited on the basis of the following criteria: women who gave birth to healthy, full term infants with a birth weight >2500 g, with time elapsed since parturition of one month (±1 week).Women suffering from any metabolic disorders, with complication in pregnancy, those which gave birth by Caesarean section and those which had history of early pregnancy loss were excluded. Women were volunteers recruited in paediatric clinics via word of mouth, with the help of their health workers, as part of a larger study of changes in dietary intake and in the fatty acids composition of human milk.

In 2009, there were 2959 new-borns in Primorsko-Goranska County, so the initially included women are a representative sample of 6% of the total number of women who gave birth to children in 2009[16]. The level of 95% confidence (p=0.05) was used. The desired level of precision for the rates of women which will be included at one month postpartum was set at ±4%. The required sample size was calculated using the equation $n = \pi(1-\pi)z^2/D^2$ [17]. In this equation, n = required sample size; π=estimated population proportion; z=1.96 (z = z-value associated with the desired confidence level of 95%); D = desired level of precision ±0.04. Required sample size was 135 but we had initially included 180 participants. Since 21 women were lost in follow-up, due to different reasons (*i.e.* absence of willingness to participate, pregnancy, moving to another part of the country, etc.), the final sample consisted of 159 women (83 lactating and 76 non-lactating), who were monitored for six months postpartum.

All women signed informed consent after being thoroughly informed of the purpose, requirements and procedure of the study. This research was conducted as a part of the national project, in which grant holder was Faculty of Food Technology, University of Osijek. Since researches were conducted also in other parts of Croatia, research protocol was approved by the Ethics Committee of this institution.

Study design and data collection

Lactating and non-lactating women were studied at three times, referred to as three measurement waves: 1 month±1 week, 3 months±1 week and 6 months±1 week postpartum. The study sample included women for whom we had three waves of data for all the variables measured. At each visit, women were asked about their lactating status and were classified according to the WHO classification as full breast-feeding, mixed-feeding and formula feeding. Full breast-feeding and mixed-feeding were considering lactating, while formula-feeding women were classified as non-lactating[18]. In each wave, a trained researcher collected data on dietary intake and took weight measurements with their own scale in the mothers' households. Additionally, during the first visit, women were asked to fill out the part of the questionnaire concerning their demographic and socioeconomic data, and also to provide some pregnancy-related data.

Dietary evaluation

Dietary evaluation was based on two consecutive 24-hour recalls (including one day of the weekend) from each woman for every measurement wave. With the aim of obtaining reliable data, the researcher conducted a multi-pass protocol for 24-hour recall. In this protocol first, respondents provides a list of all foods eaten on the previous day using any recall strategy they desired (i.e. not necessarily in chronological order). The interviewer

then obtains a more detailed list by probing for additions to these foods and by giving respondents an opportunity to recall food items initially omitted from the list. Finally, the interviewer reviews the occasions to be added if appropriate[19]. Types and quantities of consumed foods were entered into a computer programme which is based upon the Croatian Food Composition Tables[20]. Estimated energy requirements were calculated for each participant using the Dietary Reference Intake (DRI) equation for women and adding 330 kcal for fully breast-feeding and 165 kcal for mixed-feeding[21]. The requirement for protein was calculated for each participant using 1.05 g/kg/day for lactating and 0.80 g/kg/day for non-lactating women[11].

Anthropometric measurements

Measurements of body weight (kg) were taken using Body Composition Monitor Omron BF500 (Omron, Medizintechnik, Mannheim, Germany), according to the procedure described by Bosy-Westphal and co-workers[22]. Women's height was self-reported at each visit. Body mass index (BMI) was calculated as weight/height^2. Postpartum weight retention was derived by subtracting the pre-pregnancy weight from the measured postpartum weight at each measurement wave. Data on gestational weight gain and pre-pregnancy body weight were taken from the pregnancy card at first visit. For each woman, the recommended weight gain according to the Recommendations of the Institute of Medicine (IOM) was calculated, and women were categorized as having »inadequate« gestational weight gain if they gained less than the IOM recommendations, »appropriate« gestational weight gain if they gained within the IOM recommendations, and »excessive« gestational weight gain if they gained more than the IOM recommendations[23].

Statistical analysis

Since the data were normally distributed, as confirmed by the Kolmogorov-Smirov test, descriptive statistics are presented as means±standard deviations. Mean differences between lactating and non-lactating women were evaluated in two dimensions: time and group. The differences between lactating and non-lactating women at each time interval (group dimension) were established by the t-test. To examine the differences within one group (lactating or non-lactating) over postpartum time (time dimension), one-way analysis of variance (ANOVA) was conducted followed by *post hoc* Scheffe test. We fitted a multivariate longitudinal linear regression model to assess important predictors of postpartum weight retention. Eligible variables for entering the model were: type of feeding, time since parturition, gestational weight gain, average energy intake, and average energy from fat, protein and carbohydrate. For statistical analysis we used the software Statistica 8.1 (StatSoft., Inc. Tulsa, OK, USA). Testing for variables was reported to be statistically significant by using $p<0.05$.

Results

Participant characteristics

Physical characteristics and some pregnancy-related characteristics of the study sample are summarised in Table 1. There were no statistically significant differences in the characteristics of women from the two groups included in this study. The fact that for the majority of participants this was their first child, could explain the greater interest they showed in taking part in this kind of research (Table 1). According to the pre-pregnancy BMI, the majority of participants were of normal weight (70%), while 20% were overweight and 10% were obese.

Dietary intake

Daily energy intake and the intake of macronutrients among study participants are shown in Table 2. During six months postpartum, both groups of women continuously decreased their overall energy intake, and their total daily energy intake was lower by about 25% in comparison with recommendations. Lactating women, compared with non-lactating, had an energy intake higher by 205 kcal after one month ($p=0.048$) and by about 370 kcal after three months ($p<0.001$) (Table 2). Over the study period, lactating women decreased the portion of protein in their total energy intake, so after six months postpartum their protein intake was significantly lower

TABLE 1
PHYSICAL AND PREGNANCY-RELATED CHARACTERISTICS OF STUDY PARTICIPANTS

	Lactating (N=83)	Non-lactating (N=76)	All participants (N=159)	p*
Age (years)	31.82±4.60	30.52±4.51	30.69±5.05	0.074
Height (cm)	168.36±5.51	167.75±6.64	168.07±5.92	0.582
Education (years)	13.54±2.10	12.89±2.23	13.02±1.86	0.060
Number of live births	1.49±0.72	1.46±0.74	1.48±0.73	0.796
Gestational weight gain (kg)	16.17±5.34	16.97±6.74	16.53±6.03	0.406
Pre-pregnant body weight (kg)	65.20±11.28	68.25±16.55	66.66±14.06	0.173
Pre-pregnant BMI (kg/m2)	22.97±3.58	24.14±5.18	23.21±4.82	0.097

*t-test

TABLE 2
DAILY ENERGY AND MACRONUTRIENTS INTAKE (MEAN±SD) OF LACTATING AND NON-LACTATING WOMEN DURING SIX MONTHS POSTPARTUM

Parameter	Time since parturition			p-value in time dimension[a]			p-value in group dimension[b]		
	1 month	3 months	6 months	1 month *vs.* 3 months	1 month *vs.* 6 months	3 months *vs.* 6 months	1 month	3 months	6 months
Energy (kcal)									
Lactating (n=83)	2244.49±642.74	2173.68±564.65	1854.84±542.02	0.737	<0.001	0.002	0.048	<0.001	0.620
Non-lactating (n=76)	2038.66±708.94	1802.95±645.85	1801.05±549.68	0.049	0.047	0.999			
Energy (% DRI)									
Lactating (n=83)	79.52±22.70	77.01±19.88	65.73±19.25	0.777	<0.001	0.002	0.491	0.260	0.350
Non-lactating (n=76)	82.34±28.64	72.86±26.24	72.77±22.49	0.081	0.077	0.999			
Proteins (% kcal)									
Lactating (n=83)	15.73±2.86	14.50±2.93	11.22±4.58	0.607	0.481	0.632	0.101	0.011	0.009
Non-lactating (n=76)	16.52±3.12	15.77±3.35	13.18±3.97	0.294	0.035	0.585			
Carbohydrates (% kcal)									
Lactating (n=83)	49.40±6.74	50.41±6.99	52.15±6.11	0.318	0.729	0.771	0.039	0.342	0.241
Non-lactating (n=76)	51.77±7.59	49.22±8.77	50.78±8.48	0.168	0.765	0.509			
Fats (% kcal)									
Lactating (n=83)	34.87±6.25	35.10±6.48	38.06±6.56	0.973	0.006	0.013	0.605	0.002	0.036
Non-lactating (n=76)	35.40±6.65	38.73±8.32	35.94±6.05	0.031	0.131	0.816			

[a]*post hoc* Scheffe test; [b] t-test; ns – non-significant

compared with protein intake among non-lactating women (p=0.009). On the other hand, they continuously increased the portion of fat intake which was higher after three months (p=0.002) and after six months (p=0.036), compared with the intake of non-lactating women. The average share of carbohydrates in both groups was in the range of 43.21–58.14% kcal and did not change significantly through time postpartum. The daily intake of protein was higher than recommendations set by RDA for about 15%, for both group of participants.

Postpartum weight changes

Table 3 shows changes in anthropometric parameters among lactating and non-lactating women during the follow up. Although weight loss during postpartum was evident in both groups, it occurred in different timeframes and was of different intensity. For non-lactating women, weight loss was faster in the period of one to three months (p=0.049), while for lactating women significant weight loss occurred in the period of three to six months postpartum (p=0.047). When weight loss was monitored with the parameter of weight retention, which presents the difference between weight measured at certain measurement waves and pre-pregnancy weight, it could be seen that at three months postpartum, lactating women retained about 2.20 kg more than their non-lactating counterparts (p=0.001). Conversely, at six months postpartum, lactating women retained 1.33 kg compared with their pre-pregnancy weight, which is significantly lower in comparison with 4.10 kg, the amount retained in the group of non-lactating women (p=0.001). A significant convergence to pre-pregnancy weight in the group of lactating women occurred in the period of three to six months after parturition (p=0.001), while in the group of non-lactating women, a statistically significant weight loss (p=0.002) occurred earlier (namely, in the period of one to three months postpartum) and slowed down afterwards. When weight retention was expressed as a percentage of pre-pregnancy weight, it was obvious that after six months lactating women retained 101.95± 8.21% of their pre-pregnancy weight, which was significantly less than the percentage of weight retained among non-lactating women (p=0.014) (Table 3). During six months after parturition, the percentage of weight retention compared with pre-pregnancy weight for lactating women was in the range of 80.81–130.73%, while among non-lactating women it was in the range of 93.59–140.85%.

The relationship between weight retention at postpartum and daily energy intake determined with two 24-hour dietary recalls is presented in Figure 1. When weight retention was expressed in relation to the percentage of fulfilment of daily energy needs (% DRI), it could be

TABLE 3
ANTHROPOMETRIC PARAMETERS AND WEIGHT RETENTION (MEAN±SD) OF LACTATING AND NON-LACTATING WOMEN DURING SIX MONTHS POSTPARTUM

Parameter	Time since parturition			p-value in time dimension[a]			p-value in group dimension[b]		
	1 month	3 months	6 months	1 month *vs.* 3 months	1 month *vs.* 6 months	3 months *vs.* 6 months	1 month	3 months	6 months
Body weight (kg)									
Lactating (N=83)	72.12±12.56	71.68±13.35	66.54±14.08	0.978	0.028	0.047	0.240	0.485	0.047
Non-lactating (N=76)	77.02±18.49	73.26±15.08	71.07±14.39	0.049	0.005	0.067			
BMI (kg/m^2)									
Lactating (N=83)	25.39±3.95	25.23±4.24	23.43±4.52	0.983	0.025	0.013	0.250	0.048	0.040
Non-lactating (N=76)	27.02±6.31	26.56±4.18	24.96±4.82	0.042	0.152	0.841			
Weight retention (kg)									
Lactating (N=83)	6.91±4.85	6.48±5.05	1.33±5.45	0.324	<0.001	0.001	0.721	0.001	0.001
Non-lactating (N=76)	7.77±6.61	4.28±4.04	4.10±4.93	0.002	<0.001	0.110			
Percentage of pre-pregnancy weight (%)									
Lactating (N=83)	110.79±7.39	109.92±7.47	101.95±8.21	0.324	<0.001	<0.001	0.721	0.009	0.014
Non-lactating (N=76)	113.37±8.17	106.69±8.08	105.01±7.39	<0.001	<0.001	0.110			

[a] post hoc Scheffe test; [b] t-test; ns – non-significant

seen that in both groups of daily energy intake, after six months postpartum those women who breastfed their babies retained significantly less weight compared with their non-lactating counterparts (3.77 kg *vs* 5.20 kg (>100% DRI) and 1.20 kg *vs* 2 kg (≤100% DRI)) (Figure 1).

Figure 2 summarizes the results of weight retention in lactating and non-lactating women in relation to the fulfilment of recommendations for gestational weight gain. Among the entire study sample it was obvious that those women who exceeded recommendations for pregnancy weight gain retained significantly more weight than the women whose pregnancy weight gain was in accordance with recommendations. The protective effect of breastfeeding is obvious in this group since those women who were practicing breastfeeding retained about 3.75 kg after six months, which was significantly lower than the value of retained weight among non-lactating

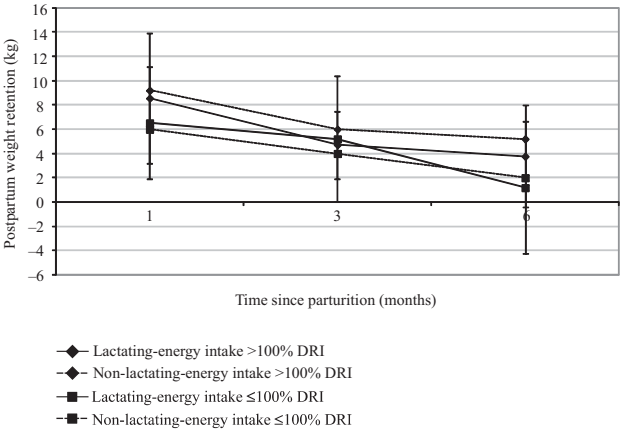

Fig. 1. Postpartum weight retention in relation to energy intake in lactating (N=83) and non-lactating (N=76) women during six months postpartum.

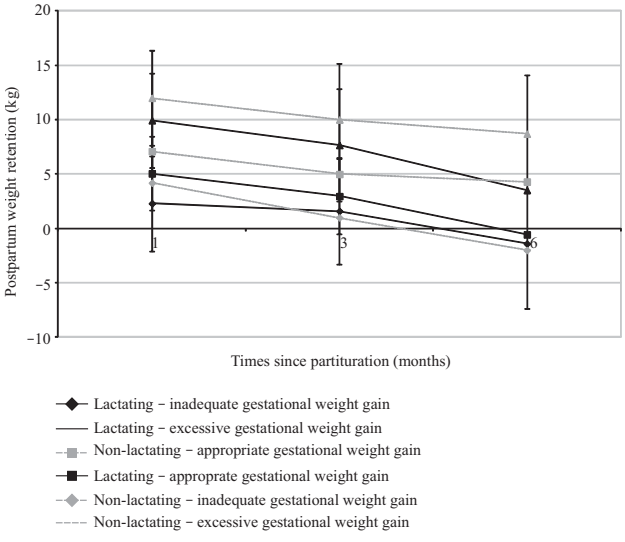

Fig. 2. Postpartum weight retention in relation to recommendations for gestational weight gain in lactating (N=83) and non-lactating (N=76) women during six months postpartum.

TABLE 4
FACTORS AFFECTING WEIGHT RETENTION IN LACTATING AND NON-LACTATING WOMEN DURING SIX MONTHS POSTPARTUM

Variable	Regression coefficient	SE	p
Type of feeding*	–0.281	0.040	<0.001
Time since parturition	–0.151	0.041	<0.001
Gestational weight gain	0.491	0.038	<0.001
Average energy intake	0.157	0.051	<0.001
Average energy from fats	0.122	0.074	0.035
Average energy from proteins	0.033	0.161	0.425
Average energy from carbohydrates	0.058	0.349	0.721

*Type of feeding was coded as 1: Lactating; 2:Non-lactating; ns–non-significant; Adjusted R^2=0.2623; p<0.05

women, which was 7.80 kg. Among the study sample whose weight gain was in accordance with recommendations, it was also obvious that in each measurement wave lactating women retained less weight in comparison with their non-lactating counterparts (*i.e.* 5 kg *vs.* 7.18 kg; 3.2 kg *vs.*5.1 kg; –0.5 kg *vs.*4.5 kg) (Figure 2).

Regression analysis

In order to obtain insight into the extent to which particular factors contributed to weight retention during postpartum, we conducted multiple regression analysis, the results of which are presented in Table 4. Based on our previously presented observations, in this multivariate regression analysis, we have chosen the following independent variables: type of feeding, time since parturition, gestational weight gain, average energy intake, and energy intake originating from macronutrients. The multiple regression analysis confirmed that gestational weight gain could be considered the strongest predictor of weight retention (β=0.491; p<0.001). Additionally, the type of feeding significantly contributed to weight retention since lactating women in comparison with non-lactating counterparts significantly retained less weight (β=–0.281; p<0.001). Those women who breastfeed longer retained significantly less weight (β=–0.151; p< 0.001). Average daily energy intake and energy derived from fat were also confirmed as statistically significant predictors of weight retention. The contributions of the intakes of the other two macronutrients (carbohydrate and protein) were statistically insignificant. All independent factors included in multiple regression analysis explained 26.23% (p<0.05) of the variability in weight retention during six months postpartum (Table 4).

Discussion

The results of this study demonstrated that the weight retained in a group of Croatian women from preconception to six months postpartum has been significantly influenced by breastfeeding practice, dietary intake and weight gained in pregnancy. Although gestational weight gain was identified as the strongest predictor of weight retention during postpartum, it was shown that breastfeeding practice for six months significantly contributes to weight loss. Six months after delivery, lactating women retained significantly less weight in comparison with their non-lactating counterparts.

Postpartum weight retention, which describes the average weight change from preconception to the first year postpartum, includes weight gain during gestation (preconception through gestation), early postpartum weight loss (delivery to six weeks postpartum), and later postpartum weight change (after six weeks postpartum)[24]. Postpartum weight is important for research since it is common[5,25], and it can negatively affect the next pregnancy, increase the risk of metabolic diseases[26], and significantly contribute to the prevalence of obesity among women later in life[27,28].

Our study has shown that the average weight retention decreased continuously and, after six months among all participants, amounted to 2.28 kg, which represents about 1.92 BMI, with a higher value among non-lactating (1.75 BMI) than among lactating (1.18 BMI) women. According to the comprehensive review by Schmitt and colleagues[28] who analysed the results of 21 cohorts and aimed to estimate the extent of time after delivery that weight is attributable to pregnancy, a decrease in weight retention was confirmed with a value of 2.42 BMI after 6 weeks and 1.14 BMI after 6 months postpartum. According to the results of pregnancy cohort studies, average postpartum weight retention from preconception to 6–18 months postpartum was 0.5 to 1.5 kg[4,8].

Among our participants at six months after parturition, 11% of lactating and 14% of non-lactating participants retained five kilograms compared with their pre-pregnancy weight. According to the research conducted by Pivarnik and colleagues[29], about 15–20% postpartum women retained at least 5 kg 6–18 months postpartum. Additionally, in our sample, about 25% of lactating and 19% of non-lactating postpartum mothers returned to their pre-pregnancy weight at six months after delivery. Women who returned to their pre-pregnancy weight by six months postpartum gained the least amount of weight over time[5]. Similar to other authors, we have confirmed that this weight retention is as much associated with modifiable lifestyle factors, including diet and breastfeeding, as with characteristics such as gestational weight gain[10,30,31].

Few recent publications have documented the relationship between energy intake and weight changes of postpartum women[18,30–33]. In the present study, although both groups of postpartum mothers significantly decreased their daily energy intake during the observed period, lactating women had a higher energy intake in one and three months postpartum in comparison with non-lactating women. Recommendations for energy intake during lactation are increased and they are based on the assumption that mothers' diets are adequate if the result is optimum growth and development of their children.

Most of the recommended intakes are based on knowledge of the amount of milk produced during lactation, its energy and nutrient contents, and the amounts of maternal energy and nutrient reserves. The recommended energy requirement during the first six months of lactation for exclusive breastfeeding women is an additional 500 kcal, assuming that 170 kcal/day will be mobilized from energy stores accumulated in pregnancy[21]. Among the group of lactating women, at one month postpartum, 19.32% of participants had an energy intake greater than 100% DRI, while at six months postpartum, due to the continuous decrease of overall food intake, only 4.85% of participants had a higher energy intake than recommended. Although lactating women had an energy intake lower by about 25% than recommended throughout the entire study time, there is no reason to concern. Today's experts agree that recommendations for energy intake during lactation are set too high, and that women who follow these recommendations lose less weight in postpartum[34]. Additionally, it was shown that women, due to the adaptive mechanism, could successfully breastfeed their infants under moderate hypocaloric intake[35]. It can be assumed that hypocaloric intake among our study sample did not have an adverse effect on breastfeeding, but at the same time, it positively contributed to weight loss. As we have seen that dietary intake declined as lactation continued, it is reasonable to expect that this allowed the pregnancy fat stores for maintenance of milk production to decline. During prolonged lactation the need to maintain body fat for help in milk production would be lessened and mobilizing the fat would be consistent with maintaining maternal health[36].

The percentages of energy obtained from macronutrient sources were in agreement with the Acceptable Macronutrient Distribution Range (AMDR) for protein and carbohydrates and were higher than the AMDR of 20–35% kcal for fats[37]. Although higher fat intake among a population of postpartum women has been confirmed in the results of other research[38–40], care should be taken since we have shown that energy derived from fat significantly affects weight retention. It has been shown that high intake of *trans* fatty acids[32] and high intake of saturated fatty acids[30]in the first year postpartum are associated with a higher risk of substantial weight retention. Obtained results of dietary intake of this vulnerable population are valuable appendix to the results of previous studies which confirmed better dietary habits of women in this part of Croatia compared with other parts of country[41,42].

Although regression analysis has confirmed that women with higher energy intake retained more weight, generally speaking, dietary factors were weaker predictors of weight retention than was the type of feeding. The fact that breastfeeding practice overrides the effect of energy intake was confirmed by the observation that in both categories of dietary intake lactating women continuously lost more weight. Lactating women started to lose weight after three months postpartum and, in the period of three to six months postpartum, their weight decreased substantially, despite their higher caloric intake compared with their non-lactating counterparts. These results confirm that in the early postpartum period, well-nourished lactating women increase energy intake to meet the energy demands of lactation, whereas beyond three months, they are more likely to mobilize fat stores[43]. By contrast, the weight of non-lactating women remained stable after three months postpartum. Weight loss among lactating women is related to fat mobilization which appears to increase after three months postpartum, and it reflects changes in the endocrine effects of lactation on maternal appetite as the frequency of infant feeding decreases. Namely, high prolactin levels in early postpartum increases maternal intake if infants' demands are high. Later in lactation, when prolactin levels have lowered, high-energy demand will promote fat mobilization[36,44]. Thus, it could be expected that lactation might promote maternal weight loss only if it is extended beyond several months[12,45]. In our study, we have confirmed that this effect is obvious even after three months. Undoubtedly, among our participants, fat mobilization and weight loss were accelerated by the previously discussed decrease in energy intake. The positive effect of breast-feeding on weight loss has recently been confirmed in a large sample of American women at six months postpartum, but without any effects at three months postpartum[11]. Generally speaking, previous findings regarding the effect of breastfeeding on postpartum weight retention have been contradictory at best. Although breastfeeding has numerous positive physiological and physical effects on mothers and children, most studies have confirmed greater weight loss in breastfeeding women[8,10,11,12], while in other studies the relationship between breastfeeding and weight loss has not been established[7,9].

The identification in this study of gestational weight gain as the strongest predictor of weight retention is consistent with data which has been reported by other authors[5,11,46]. Gestational weight gain is the net effect of foetal growth, maternal organ adjustment and energy balance during pregnancy. The recommended weight gain during pregnancy is 10 to 16 kg, depending on the BMI before pregnancy[23]. Experts strongly advice pregnant women to take care about weight gain during pregnancy, since excess weight gain in this period of life significantly increases the risk of premature birth, macrosomia and congenital malformations[44], and it could also be a primary contributor to the future development of obesity[5]. The average gestational weight of our study sample (16.53 kg) was similar to the weight gain of a U.S. population, among which, similar to other developed countries, there is an obvious trend of pregnancy weight gain increase from an average of 10 kg in the 1960s to 15 kg by the late 1980s[25]. The percentage of women (39%) in our study who gained more weight during pregnancy is similar to the recent data from the U.S.A. showing that about 43% of pregnant women gain more in pregnancy than is recommended[47]. Several studies have confirmed that women who gain more weight in pregnancy also retain

more weight after delivery[15,27]. Gunderson and colleagues[25] reported that gestational gain above the recommended levels was associated with a threefold higher risk of becoming overweight after pregnancy among women who were underweight or of average weight before pregnancy in a large cohort.

In addition to gestational weight gain, the most independent risk factors for excessive weight retention during postpartum are maternal overweight or obesity before pregnancy[8]. Obese women during pregnancy mobilize less body fat and consequently they retain more weight after delivery. In our previous work we have confirmed that among the same study sample those women who were already overweight before pregnancy tended to retain and gain more weight after pregnancy compared with average weight women[48]. This fact is of special concern in the light of fact that in the last 25 years Croatian women of childbearing age continuously increase their pre-pregnancy weight[49].

The strength of the present study lies in the fact that it is the first study to document the dietary intake of Croatian women, combined with lactation practice, in relation to weight retention. In this prospective study, dietary intakes were recorded and weight measurements were conducted without interfering in the participants' lives. We also had a low rate in losing follow-ups. Since the presented results are part of a comprehensive study in which we also determined the fatty acid composition of breast milk and provided mothers with this information, we assume that that is the reason why women were highly motivated to participate in the study. However, our study has a few limitations. One possible limitation is that participants had a narrow distribution of socio-economic status, probably because the study used a volunteer population in which those who were of lower socio-economic status had no willingness to participate. The majority of our participants were primiparous, which is to be expected, because these women have more interest to participate in this kind of study. However, primiparity is highly correlated with postpartum weight retention, so this could be a source of bias in this research. Lastly, we have combined data of fully-breastfeeding and mixed breastfeeding women into one category for type of feeding. This strategy did not allow looking into the importance of exclusive breastfeeding on weight change.

Conclusion

Regardless of the mentioned methodology issue, in this study we have presented empirical evidence that breastfeeding *per se* must be sustained for six months postpartum for a significant impact on weight loss. Although lactating and non-lactating women continuously lost weight during postpartum, after three months, non-lactating women stopped losing weight, while lactating women at six months after delivery retained significantly less weight in comparison with non-lactating women. Additionally, gestational weight gain and dietary intake were also predictors of weight retention. Within this context, pregnant Croatian women should be advised to control their weight gain in pregnancy, breastfeed their infants for at least six months, and decrease energy and fat intake during postpartum in order to reduce excessive postpartum weight. Further investigation is needed to confirm the link between exclusive breastfeeding and weight retention during postpartum.

Acknowledgements

Sincere thanks to all women who have participated in this study.

Source of funding

This research was conducted as a part of the national project Nutrition and lifestyle in health protection (No. 113-0000000-0548) financed by the Ministry of Science, Education and Sports of the Republic of Croatia.

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PROMJENE PREHRAMBENOG UNOSA I TJELESNE MASE DOJILJA I NEDOJILJA: PROSPEKTIVNA STUDIJA U SJEVERNOM HRVATSKOM PRIMORJU

S A Ž E T A K

Tjelesna masa zadržana nakon poroda je rizični čimbenik za pojavu pretilosti kasnije tijekom života.. Budući da dojenje i prehrambeni unos tijekom poslijeporođajnog razdoblja mogu utjecati na smanjenje tjelesne mase, cilj ove studije je ispitati njihov utjecaj na zadržanu masu tijekom šest mjeseci poslijeporođajnog razdoblja. Istraživanje je uključilo 83 dojilje i 76 nedojilja koje su praćene kroz tri posjeta: 1 mjesec ±1 tjedan, 3 mjeseca ±1 tjedan i 6 mjeseci ±1 tjedan nakon poroda. Tijekom svakog posjeta, provedeno je dijetetičko ispitivanje primjenom metode 24 satnog prisjećanja za dva uzastopna dana te je izvršeno vaganje ispitanica. Dobiveni rezultati su pokazali da obje grupe ispitanica imaju dnevni energetski unos za 25% manji od preporuka. Premda je u obje skupine zamjetno kontinuirano smanjenje unosa energije i makronutrijenata, dojilje su za razliku od nedojilja imale veći unos energije za 205 kcal ($p=0,048$), odnosno 370 kcal ($p<0,001$) nakon 3 odnosno nakon 6 mjeseci. Šest mjeseci poslije poroda dojilje su u usporedbi sa nedojiljama imale veći unos masti ($p=0,036$) ali niži unos bjelančevina ($p=0,009$). Nakon šest mjeseci poslijeporođajnog razdoblja dojilje su zadržale 101,95% svoje mase prije trudnoće što je značajno u usporedbi sa nedojiljama (105,01%) ($p=0,014$). Među ispitanicama koje su imale prirast tjelesne mase u trudnoći u skladu s preporukama, zamjetno je da su tijekom poslijeporođajnog razdoblje one koje doje imale konstantno manju zadržanu masu nego nedojilje. Rezultati multiple regresijske analize su pokazali da su prediktori zadržane tjelesne mase tijekom poslijeporođajnog razdoblja: tip hranjenja dojenčeta ($\beta=-0,281$; $p<0,001$), vrijeme nakon poroda ($\beta=-0,151$; $p<0,001$), prirast mase u trudnoći ($\beta=0,491$; $p<0,001$), energetski unos ($\beta=0,157$; $p<0,001$) i udio energije podrijetlom iz masti ($\beta=0,122$; $p=0,035$).